Montana Environmental Health Association

PO Box 741, Helena, MT 59624

SENATE
PUBLIC HEALTH, WELFARE & SAFETY
Exhibit No. 9
Date 4/8/2015
Bill No. HB 245

April 7, 2015

Senate Public Health, Welfare and Safety Committee
Senator Thomas, Committee Chair
P.O. Box 200500
Helena, MT 59620

RE: **LETTER OF OPPOSITION**

HB 245- Establishing a Small Herd Exemption Permit and Fee for Certain Producers of Milk and Providing for Herd Sharing

Dear Senator Thomas, Chair, and Members of the Committee:

The Montana Environmental Health Association is an organization of public health professionals such as Registered Sanitarians, environmental consultants, and other health professionals dedicated to protecting our everyday environment. A few areas that Registered Sanitarian's strive to ensure the daily health of for the public are Montana's licensed food establishments, public water systems, air quality and wastewater systems.

For reasons too numerous to list, this organization does not support HB-245. Please consider the following:

- **Pasteurization of milk is a public health success.** The benefits of milk pasteurization in the United States dates back to the mid 1800's. Scientists Robert Koch and Lois Pasteur had discovered that diseases such as bovine tuberculosis were transferred through milk. As early as 1860 Louis Pasteur had discovered that if milk and other beverages were heated, pathogens were killed. Buy in for pasteurized milk took nearly 30 years in the U.S. It wasn't until 1912 and 1913 when ordinances in Chicago and New York were passed and the rest of the country followed suit. Illnesses such as typhoid fever and tuberculosis were drastically reduced by pasteurization. The impact of pasteurized milk on public health was nothing short of astounding. In 1885 the infant mortality rate in New York City was 273 per 1,000 live births -more than 27%. By 1915 the infant mortality rate was 94 per 1,000, - 9.4%. **Reversing known public health protections, especially for children and other immune compromised populations, is illogical and not protective of the public's health.**

-**Science supports the need for milk pasteurization.** Agencies such as the American Medical Association, American Veterinary Medical Association, Centers for Disease Control and Prevention, Food and Drug Administration, American Academy of Pediatrics and the National Environmental Health Association **endorse pasteurization and advise against the consumption of raw milk** because the health risks associated with raw milk outweigh any benefits.

-Herd Share milk products DO NOT require testing. The bill will allow for herd shares, which is different than the small herd exemption. Herd share produced milk will **NOT** require any safety testing; this means no tuberculosis, brucellosis or other bacterial testing is required (page 2, line 20 of bill draft). There is no limit on herd size for herd shares, meaning an UNLIMITED quantity of raw milk without testing will be available.

-All assumed risk is placed on the consumer. Per the bill draft, "the consumer assumes liability for the health issues that may result from the consumption of this product". There is a clear acknowledged risk in drinking unpasteurized milk. Per the CDC, there are higher outbreaks in states which have legalized raw milk versus those that have not. Creating a statement simply assigning risk to the consumer is not protective of public health, especially children and other immune compromised sectors.

We urge you to vote NO on HB 245. The health risks associated with consuming unpasteurized milk are not always clear to the public. Children may not have a choice when consuming raw milk. **Please reduce health risks to the public by voting NO to HB 245.**

Sincerely,
Christine Hughes, R.S.
Christine Hughes
MEHA Legislative Committee Co-Chair

Linda Stoll

A Literature Review of the Risks and Benefits of Consuming Raw and Pasteurized Cow's Milk

A response to the request from The Maryland House of Delegates' Health and Government Operations Committee

December 8, 2014

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<u>Executive Summary</u>

A bill entitled "House Bill 3, *Health - Milk Products - Raw Milk - Consumer-Owned Livestock*" was introduced to the Maryland House of Delegates during the 2014 session of the General Assembly. In response to concerns regarding the public health and safety of allowing the sale of raw milk directly to consumers, the Health and Government Operations Committee requested a review of the benefits and risks of drinking raw cow's milk and pasteurized (i.e. heat-treated) milk. This review aims to provide an objective evaluation of the claims that health benefits of raw milk outweigh any potential risks.

We examined the scientific literature for research regarding the health benefits and risks of raw and pasteurized liquid bovine milk. Based on a rigorous search strategy, we identified more than 1000 scientific articles for consideration in our review. We then reviewed abstracts of these articles to narrow the study database to articles that fit our scope. After eliminating articles that were not informative to the questions posed, our screening process resulted in the inclusion of 81 articles from the peer-reviewed literature.

Based on our review of the scientific evidence, we conclude that drinking raw milk carries an increased risk of foodborne illness as compared to drinking pasteurized milk. We identified several articles that detected a relationship between drinking raw milk and reduced allergies among rural children and infants. The underlying cause for this relationship, however, has not been identified. While some articles noted nutritional deficiencies in pasteurized milk, these can be overcome by eating a well-balanced diet. Overall, our review identified no evidence that the potential benefits of consuming raw milk outweigh the known health risks.

Based on our findings, we discourage the consumption of raw milk. The risks of consuming raw milk instead of pasteurized milk are well established in the scientific literature, and in some cases can have severe or even fatal consequences. The potential benefits on the other hand, are still unclear and would benefit from further investigation. We are left with a large uncertainty about the potential benefits of raw milk but with a clear understanding of the microbial hazards from consuming raw milk.

We believe the scope of the review and the employed search methods are unbiased and representative of the available scientific literature; only future research will remove current uncertainties. While future research could inform decision-making on the legalization of raw milk, we believe that from a public health perspective, it is a far safer choice to discourage the sale of raw milk. Regardless, we believe that the potential health risks of consuming raw milk should be clearly communicated, especially to vulnerable populations such as pregnant women, children, and the elderly.

Introduction

Cow's milk has been a staple of the American diet ever since the medical community publicized its nutritional benefits in the 1920s (Mendelson 2011). However, health concerns over cow's milk began as early as the mid-19th century, when the public began to focus on unhygienic conditions of cows and dairy processing plants. Foodborne illnesses from consuming milk were common during this time, and were mostly due to bacterial contamination (Garber 2008; Gillespie et al. 2003). Foodborne illnesses are often limited to ephemeral symptoms such as nausea, vomiting, and diarrhea, but can also include more serious and chronic complications, such as hemolytic uremic or Guillain–Barré syndromes; in some cases illnesses can lead to death (U.S. Food and Drug Administration 2012a).

In response to the public's concerns, regulators and hygienists improved the practices of caring for and milking cows as well as how milk was distributed to consumers (Gould et al. 2014; Leedom 2006). At a similar time, a heat-treatment process that could kill microbes, known today as pasteurization, was introduced to further ensure milk safety. Pasteurization requires heating milk to a specific temperature for a minimum period of time, and then quickly cooling it back down to refrigeration temperatures (4°C) (De Buyser et al. 2001; Walstra et al. 2006). Many heat-time combinations are effective (**Table 1**). Classic pasteurization involves heating milk to 63°C for 30 minutes. However, as pasteurization became widely accepted and dairy plants became more industrialized, higher temperature-short time pasteurization (HTST; 72°C for 15 seconds) and ultra-high temperature pasteurization (UHT; 135°C for 2 seconds) became commonplace (Mendelson 2011; Walstra et al. 2006).

In the mid-1950s states began banning the sale of "raw" (i.e. unpasteurized) milk (Mendelson 2011), and in 1987 the U.S. Food and Drug Administration (FDA) prohibited the interstate shipment and sale of raw milk for human consumption (Langer et al. 2012). These laws, along with more hygienic farm practices, reduced milkborne outbreaks from almost a quarter of all reported intestinal infectious diseases to <1% (Lejeune and Rajala-Schultz 2009). Since its ban, however, demand for raw milk has persisted and grown along with the public's interest in "whole" and "organic" diets (David 2012). There have also been claims that raw milk is cleaner and has a superior taste to pasteurized milk (Lejeune and Rajala-Schultz 2009). For the past 15 years media coverage of raw milk has expanded, reflecting the communication and outreach of raw milk advocates (Mendelson 2011). Currently 30 states permit the sale of raw milk, usually allowing small amounts to be sold directly at local farms or through "cow share" programs (Gould et al. 2014). Some of these efforts have illegally expanded into interstate sales. For example, raw milk produced in Pennsylvania has been sold in Maryland, which has resulted in litigation from the FDA (David 2012). It is currently estimated that 0.5-3.5% of the U.S. population drinks raw milk, with the majority of these people residing on farms (Lejeune and Rajala-Schultz 2009). In recent years, there has been an increase in raw milk availability, which has concerned public health officials, as they believe this may increase the risk of foodborne illness (U.S. Food and Drug Administration 2012b).

The greatest and most widespread concern of overall milk safety is microbial contamination: the presence of infectious bacteria or viruses. Pathogens commonly found in milk include: *Salmonella* species, *Campylobacter jejuni*, Shiga-toxin producing *Escherichia coli* (STEC), and *Listeria* *monocytogenes*. These bacteria are also found naturally in the environment. Cows can be exposed to environmental sources of microbes on the farm, which can cause mastitis, an infection of the udders that can spread pathogens during milking (Lejeune and Rajala-Schultz 2009). Fecal contamination from the cows during milking can also allow high amounts of pathogenic microbes to enter the milk.

During large-scale pasteurized milk production, unprocessed milk is sent from dairy farms to dairy processing plants in bulk tanks where large quantities of milk are stored (Oliver et al. 2005). Bacteria and viruses can grow in these tanks and spread to previously uncontaminated milk. It is at this point in the milk production process, however, that milk is usually pasteurized, and, assuming the heat treatment is performed appropriately, most pathogens will not survive (Oliver et al. 2005; Walstra et al. 2006). Post-pasteurization contamination, however, is possible, usually through microbial biofilms in distribution pipes, unhygienic practices of employees, or the use of unsterilized containers or post-pasteurization equipment (Leedom 2006; Lejeune and Rajala-Schultz 2009; Oliver et al. 2005). The risk of microbial transmission also occurs via dairy workers at all points during milk processing, including the equipment and practices on the farm (Leedom 2006). After milk is distributed, failure to keep milk at refrigeration temperatures can allow pathogenic microbes to multiply, greatly increasing the risk of illness from consuming the milk. Improper storage can be the fault of the dairy distributors, but also retail workers and milk consumers (Gould et al. 2014). So, while pasteurization can reduce microbial contamination, it does not ensure that milk is sterile throughout the supply chain (Lejeune and Rajala-Schultz 2009).

Often, there are systematic differences between the large-scale milk production described above and small-scale dairy farming, where raw milk is commonly sold (Mendelson 2011). These differences may influence the risk of microbial contamination in milk. Cattle on small farms are often not confined to dense, industrial sheds and may graze on nearby grass instead of being fed soy and corn from elsewhere. Raw milk for sale is typically not stored in bulk tanks and the distribution of milk is usually minimal, with most customers purchasing on the farm. While cross-contamination of milk after collection is reduced, the risk of contamination during collection remains (e.g. fecal contamination or mastitis of cow udders). Because small-scale farmers may not be subject to state and federal sanitary regulations and testing, there may be greater likelihood of some raw milk being contaminated with hazardous microbes and thus pose a risk to consumers.

Cow's milk has multiple benefits including its nutritional value (Mendelson 2011). In recent years there have been claims that raw milk can reduce allergic reactions and cure other ailments (Ijaz 2013). Allergies are a symptom of autoimmunity, which is characterized by the immune system attacking its own body (Melnik et al. 2014). The frequency and prevalence of autoimmunological conditions, such as asthma, have been increasing in recent decades, and some believe that living in too sterile of an environment may contribute to this increase. This "hygiene hypothesis" could be the reason why some believe that drinking unpasteurized milk, which contains many natural proteins, antibodies, and microbial communities, may reduce these public health risks (Baars 2013; Hodgkinson et al. 2014). However, recent reports have asserted that these potential health benefits have not been sufficiently investigated (Macdonald et al. 2011).

In the 2014 session of the Maryland General Assembly, a bill was introduced in the House of Delegates that would allow for the limited distribution of raw milk intended for consumption in the state via "cow shares" (Hubbard 2014). The Health and Government Operations Committee requested that the authors conduct a literature review on the benefits and risks of consuming raw milk and pasteurized milk. This review is intended to be an objective evaluation of the claims that health benefits of raw milk outweigh any potential risks. Below is the description of the literature review, a summary of its results, and an interpretation of the findings.

Methods

Our charge from the Maryland House of Delegates was to review the scientific literature concerning the risks and benefits of both raw and heat-treated (i.e. pasteurized) milk. Due to time and resource limitations, the scope of our review was limited to direct comparisons of health risks for raw and pasteurized fluid bovine milk. Articles discussing nutrition, spoilage (from an aesthetic perspective), or taste were excluded from the review, except when such articles also discussed other health risks. We considered these topics less pressing, as they are not, in the context of milk consumption, primarily public health concerns. While overall nutrition is important to the public's health, vitamins and proteins found in milk are found in other staple foods (Macdonald et al. 2011; Mendelson 2011), and thus milk is not essential to an individual's diet. Spoilage and taste are more economical and consumer-preference concerns and so were not considered health benefits. We also excluded literature that focused exclusively on non-bovine milk or other dairy products such as cheese, buttermilk and yogurt. Many of these products undergo a fermentation process, and the U.S. Food and Drug Administration considers some cheeses made from raw milk safe (Gould et al. 2014).

Our literature search was conducted in PubMed, the most relevant database for English health-focused scientific literature. Relevant articles were found using specific search terms, (**Appendix A**). While there may be additional relevant articles that were not included in our search results, there is no reason for us to believe that our search method significantly biased the search returns. We therefore consider our review representative of the scientific literature. We reviewed all titles and abstracts of returned database articles and determined whether they were pertinent to the topic of raw and pasteurized milk public health benefits or risks. Articles considered relevant were then grouped into categories based on the type of public health risk and what dairy products were evaluated. We fully reviewed all articles within our aforementioned scope and that were published in the last 15 years (i.e. after 1998).

Articles and documents recommended for this review by interested citizens (and forwarded to us by the Committee) were also considered. These articles went through the same review process as described above unless they were already identified through the database search results.

Results

Selection of articles for review

Our search was conducted in the PubMed database on July 27, 2014. Of the 1,006 articles returned, 659 were not considered relevant and so were not fully reviewed. These excluded articles often focused on the accuracy of new microbiological assays to detect bacteria in milk products, as opposed to persistence of natural bacteria concentrations in milk. Other studies focused on rural and impoverished international settings where raw milk is the only type of bovine milk available for consumption. Other articles focused only on human breast milk, soymilk, or changes in raw milk composition based on dairy feeding practices. Still others focused on public health risks that were not relevant to the U.S. such as tick-borne encephalitis in milk, which is currently only a concern for central and eastern European countries. This last set of articles could have been included, as they could potentially become risks of U.S. milk consumption in the future.

The remaining 347 articles considered relevant to the charge given by the Maryland House of Delegates were further separated into categories. These categories included non-bovine/non-fluid milk, public health benefits, and public health risks. Complete information on these sub-categories is available in **Appendix B**. As mentioned above, we restricted our review's scope to direct comparisons of public health concerns for raw and pasteurized bovine fluid milk. Of the 172 articles within this scope, some were not reviewed because it was difficult or impossible to access the article or because the article had not been translated into English. A total of 48 were therefore additionally excluded. Finally we restricted our review to articles published in the last 15 years. After all exclusions, 81 articles were fully reviewed (list available in **Appendix C**). **Figure 1** depicts our review process.

Two additional articles that were not returned by our search but were frequently referenced by papers retrieved were also included in our review (Langer et al. 2012; Latorre et al. 2011).

Some of the reviewed articles also mentioned nutrients and other milk components. While these topics were not in our scope, details from these articles were included in our review. Some fully reviewed articles were determined to be outside of our aforementioned scope or were articles from magazines and other non-peer-reviewed sources that simply reiterated information from other primary scientific articles. These articles are therefore not mentioned in the following results.

Our review of the included articles is organized into the following sections: outbreak reviews, microbiological hazards in milk, allergies, lactose intolerance, and milk consumption, non-microbial hazards in milk, and other public health risks, and milk nutrition.

Outbreak reviews

Almost every article reviewed on the topic of milk-related outbreaks directly stated that pasteurization substantially reduces the risk of microbial contamination and should always be strongly recommended or required (e.g. (Langer et al. 2012) (Lejeune and Rajala-Schultz 2009) (Gould et al. 2014) (David 2012)). Many studies have investigated microbial risks by reviewing outbreaks of infectious intestinal diseases reported to health agencies in the United States and other countries. As infections from pathogenic bacteria and viruses are sporadic, epidemiologists rely on determining causes of outbreaks through retrospective analyses of surveillance data. (Langer et al. 2012) provides one of the most extensive reviews of outbreaks from both nonpasteurized and pasteurized dairy products. This article identified 121 outbreaks from 1993-2006 associated with dairy products through the Centers for Disease Control and Prevention's (CDC) Foodborne Disease Outbreak surveillance system. 60% of these outbreaks were from nonpasteurized dairy products. Only 36% of total cases (i.e. infected individuals) from all the outbreaks were from nonpasteurized dairy products, but among these cases there was a higher proportion hospitalized; 13% as opposed to the 1% hospitalization rate from pasteurized dairy product cases. Individuals affected by nonpasteurized outbreaks were more likely to be young children and to reside in states that permit the sale of nonpasteurized milk. The authors found that half of the pasteurized dairy product outbreaks were caused by norovirus, a pathogen with a human reservoir and therefore likely contaminated products post-pasteurization. This study highlighted the high proportion of nonpasteurized outbreaks, especially considering that consumption rate of nonpasteurized dairy products ranges from 1-3.5% of all dairy products. The authors estimate that the relative risk of individual illness is almost 150 times greater per unit of nonpasteurized dairy product, compared to pasteurized.

Similar findings were observed in other reviews of outbreaks. (Lejeune and Rajala-Schultz 2009) mentions numerous additional raw milk outbreaks reported to the CDC since 2006. (Newkirk et al. 2011) looked at U.S. milkborne outbreaks from 1990-2006 and found that 55.4% of the 83 outbreaks were associated with unpasteurized milk. (Oliver et al. 2009) found that from 2000-2008, 8 of 10 U.S. milkborne outbreaks were due to consuming raw milk. (Leedom 2006) mentions a study that reviewed 23 foodborne outbreaks from 1980-1982 caused by *Campylobacter* species; 14 were associated with raw milk. (Gillespie et al. 2003) reported milkborne outbreaks in England and Wales from 1992-2002. Fifteen of the 27 outbreaks during this time period were from unpasteurized milk, mostly due to *Salmonella* species, *Escherichia coli* strain VTEC O157 and *Campylobacter jejuni*. Finally, (De Buyser et al. 2001) reviewed reported outbreaks from France, U.S., Finland, Netherlands, UK, Germany, and Poland. Of the 22 milkborne outbreaks considered, 10 were from raw milk, and of the 27 cheese-associated outbreaks, 21 were from cheese made from raw milk.

When considering these outbreak reviews, it is important to emphasize the difference in consumption rates of raw and pasteurized dairy products. As only a small fraction of U.S. and European populations consume raw dairy products, the proportion of associated illnesses is considerably large. While nothing short of a clinical trial could remove all the potential confounding that underscores any outbreak review, these studies do indicate that raw milk carries a substantially larger risk of pathogenic microbial contamination and subsequent human illness, when compared to pasteurized milk.

Microbiological hazards in milk

(Grant et al. 2002a) conducted a survey of bacteria prevalence in milk samples in the United Kingdom from 1999-2000. Investigators surveyed 258 of the 754 approved dairy processing plants in the UK for bulk raw and pasteurized milk. Analysis of samples revealed that raw milk had far higher prevalence of coliforms, *E. coli*, and *Listeria* species. A few bulk raw milk samples also contained the pathogenic *E. coli* strain O157, as well as *Salmonella* and *Campylobacter* species; almost none were detected in pasteurized milk.

A study performed in Italy investigated bacterial levels in raw milk purchased from vending machines (Tremonte et al. 2014). The Italian Ministry of Health requires that raw milk purchased from vending machines be stored at 4°C for no more than 72 hours, and should be boiled before consumption. This study showed that total bacteria increased significantly in raw milk during the 72hrs of storage at 4°C. Boiling was able to sanitize the milk, resulting in undetectable bacterial counts. Interestingly, microwaving the milk at 900 watts for 75 seconds also sanitized the milk to undetectable microbial levels, but did not recapitulate the drastic loss of whey protein that results from boiling. This study draws attention to heating milk as important for sanitation, but suggests that microwave treatment should be investigated as an alternative to boiling (Tremonte et al. 2014).

Although outbreak records and microbial milk analyses are useful, it is still difficult to precisely quantify the bacterial risk of consuming raw versus pasteurized milk. A recent study by (Giacometti et al. 2012) attempted to address this by performing a quantitative microbial risk assessment for campylobacteriosis, caused by *Campylobacter jejuni,* and for hemolytic uremic syndrome (HUS), caused by verocytotoxin-producing *E. coli,* from consuming bottled raw milk in northern Italy. The investigators performed a full exposure assessment, from milking to consumption, considering variation in refrigeration, storage, and heating of raw milk. The investigators found that there was annual risk equivalent to 1-2 cases of campylobacteriosis and 0.01-0.02 HUS cases for every 10,000-20,000 consumers. The investigators were confident that the overall risk would increase if the entire population of Italy was considered, and estimated that 2-11 cases of HUS caused by consuming raw milk occurred in the country between 2007-2011.

The FDA performed a similar risk assessment for *Listeria monocytogenes* in multiple ready-to-eat foods (Whiting et al. 2003). When directly compared, unpasteurized milk had almost a 7 times greater risk of infection per serving than pasteurized milk, although this difference was not statistically significant. However when considering the frequency of consumption, far more listeriosis cases were estimated annually for pasteurized milk than for unpasteurized milk (90.8 vs. 3.1). This calculation was made assuming that raw milk accounts for only 0.5% of all fluid milk consumed in the U.S., and the authors noted that the number of cases attributed to raw milk would increase substantially if raw milk was more frequently consumed. A recent publication updated this risk assessment and calculated a significantly lower overall risk for raw milk, but also found that, when compared to pasteurized milk, the risk per serving was ~117 times greater (Latorre et al. 2011).

A number of specific pathogenic bacteria were examined in other articles; they are discussed below. Please note, when we refer to "genetic material," there is no proof an actual living microorganism was present. For example, microbial genetic material can still be found after heat-treatment has killed a pathogen in milk. Although live bacteria are able to be detected, it is done using other methods not involving genetic material.

Listeria monocytogenes is a gram-positive aerobic non-spore-forming bacterium. Although rare, listerial contamination of dairy products can cause serious illness. These bacteria can thrive in refrigeration temperatures (4°C) and can lead to listeriosis, bacteremia, meningitis, and death for fetuses, children, the elderly, and the immune-compromised. (Baek et al. 2000) reported that in a survey of food products in South Korea, 4.4% of raw milk products were contaminated with *Listeria* species genetic material, while none were found in pasteurized milk and cheese. This study also mentions that *Listeria* species have been found in pasteurized milk in other countries, for example 1.1% of samples in a United Kingdom survey, but that these were likely due to post-pasteurization contamination. (Mathew and Ryser 2002) investigated growth of *Listeria* bacteria that was artificially added into raw and pasteurized milk. The authors found the bacteria were much less likely to grow in raw milk, possibly because of the competing microflora. Another study reported similar results, where four different strains of *Listeria monocytogenes* were artificially incubated in raw or pasteurized milk for 24 hours at 4°C (Pricope-Ciolacu et al. 2013). These strains displayed improved virulence when incubated in pasteurized milk, and decreased virulence when incubated in raw milk. These results indicate that the milk environment can impact the virulence of this pathogen, and underscores the importance of preventing post-pasteurization contamination.

Escherichia coli are gram-negative bacteria commonly found in the intestines of birds and mammals. Only a small subset of this group of bacteria is pathogenic to humans (e.g. *E. coli* strain O157). For European children under the age of 3, this strain of *E. coli* has caused illnesses solely from drinking raw milk (Baars 2013). While pasteurization will kill all *E. coli* bacteria, (Peng et al. 2013) investigated whether subpasteurization, or "thermization", would still be effective in order to retain the claimed health benefits of raw milk. The authors found that thermization did not kill all *E. coli* but, but no pathogenic *E. coli* survived. (Alhelfi et al. 2012) showed that contaminated milk, whether raw or pasteurized, will see proliferation of *E. coli* O157 if allowed to reach room temperature for 2 hours, reemphasizing the need to properly store milk at refrigeration temperatures. (Massa et al. 1999) also found that storing contaminated raw milk at 8°C, for 1-2 weeks allows *E. coli* O157 to survive and even proliferate.

Campylobacter jejuni are gram-negative bacteria that are ubiquitous throughout the environment. They can be present in milk due to fecal contamination during milking or through mastitis in udders. These bacteria can cause campylobacteriosis and in some cases Guillain-Barré syndrome. (Doyle and Roman 1982) inoculated *C. jejuni* bacteria into unpasteurized and pasteurized milk. The authors found that *C. jejuni* bacteria levels decreased more rapidly in unpasteurized milk than pasteurized, most likely due to competing microflora. The authors do note the need to pasteurize milk, as *C. jejuni* can be found in unprocessed milk.

Yersinia entercolitica can grow at refrigeration temperatures. Although they are usually not a concern, they can cause gastroenteritis in susceptible populations such as children. (Soltan-Dallal et al. 2004) found that 1.6% of raw milk samples from northern Iran tested positive for *Y. entercolitica* genetic material while none of the HTST pasteurized milk samples tested positive.

The investigators recognized that other studies have found these bacteria in pasteurized milk samples, but this was usually a result of post-pasteurization contamination.

Helicobacter pylori are common parasite infections in humans, usually acquired during childhood from a variety of sources including drinking water and unpasteurized sheep's milk. (Fujimura et al. 2002) collected bovine milk samples across Japan and found 72.2% of raw bovine milk and 55% of pasteurized milk contained genetic material for the parasite. However, investigators could only isolate live *H. pylori* in one raw milk sample. The investigators concluded that *H. pylori* could not survive pasteurization, but that post-pasteurization contamination is possible.

Staphylococcus aureus bacteria cause a large number of human infections and can be found throughout the environment. Food handlers and animals can act as reservoirs, and the bacteria can cause mastitis in cows. (Rodriguez-Rubio et al. 2013) assessed the effectiveness of exogenous lytic enzymes to act as antimicrobials on these bacteria in milk. They found the enzyme CHAPSH3b was particularly effective at destroying these bacteria, more so in raw milk than pasteurized milk. The investigators concluded this was because high temperatures destroyed CHAPSH3b and thus recommended that the enzyme only be included after pasteurization of milk was complete.

A type of bacteria known as *Mycobacterium avium* subspecies *paratuberculosis* (MAP) raised some concerns during the 2000s. MAP bacteria can cause a chronic gastrointestinal illness in cattle known as Johne's disease, and there is currently an unresolved association between MAP and Chron's disease in humans. A number of studies have evaluated the presence of MAP in raw and pasteurized milk. Two systematic reviews of the MAP literature found mixed findings, but overall observed that while pasteurization can inactivate MAP, viable bacteria can still be found in milk after pasteurization (Eltholth et al. 2009; Waddell et al. 2008). Five articles in our review found MAP genetic material in pasteurized milk, but no viable bacteria (Ayele et al. 2005; Gao et al. 2002; O'Reilly et al. 2004; Skovgaard 2007; Stabel 2000), while three studies were able to detect viable MAP bacteria in pasteurized milk (Gao et al. 2002; Grant et al. 2002b; McDonald et al. 2005).

Another *Mycobacterium* species, *M. bovis*, can cause tuberculosis in cattle and in humans drinking contaminated milk. (de la Rua-Domenech 2006) notes that while pasteurization prevents against such risky contamination, there is a growing concern as raw milk consumption increases in the United Kingdom. The author concludes that more rigorous cattle inspections will be required to mitigate the growing risk. Fortunately, in the early 20th century great efforts were made to remove *M. bovis* from U.S. cows and these bacteria rarely found in U.S. milk today (Lejeune and Rajala-Schultz 2009). However if the bacteria species again invaded U.S. cattle, the risk of tuberculosis from consuming raw milk would rise significantly. (de Kantor et al. 2010) noted recent outbreaks of *M. bovis* in parts of San Diego, California, but these were likely due to eating unpasteurized soft cheeses imported from Mexico.

Arcobacter species are considered emerging enteropathogens, with *A. butzleri* being the most prevalent. These bacteria produce similar symptoms to campylobacteriosis but are more persistent in the natural environment. (Giacometti et al. 2014) studied growth and survival of *A. butzleri* and *A. cryaerophilus* that were added "post-processing" to raw, pasteurized, and UHT milk and were then stored for six days. They found at refrigeration temperatures that both species remained viable in all types of milk. At room temperature, *A. butzleri* levels increased in pasteurized and UHT milk but became non-viable in raw milk. The authors note that this decrease of these bacteria in raw milk was likely due to competition from other microflora. However, since storing milk at room temperature is never recommended these findings are not relevant. The authors concluded that contamination is mostly a concern during "post-pasteurization" as effective pasteurization will likely remove most if not all *Arcobacter* species.

Aeromonas bacteria cause gastroenteritis, and are commonly isolated from a variety of food products. These species are able to grow at refrigeration temperatures, thus posing a threat to human health if present in milk. (Melas et al. 1999) tested many raw and pasteurized milk samples from Northern Greece, and found that 40% of raw milk samples were positive for live *Aeromonas* bacteria, including *A. hydrophila*, *A. caviae*, and *A. sobria*. *Aeromonas* species were not detected in any pasteurized milk samples.

Coxiella burnetti are found worldwide and can cause an illness commonly referred to as "Q fever". While these bacteria are mostly a hazard for individuals in direct contact with farm animals, there is some concern about exposure through raw milk. However the CDC considers this exposure rare. (Eldin et al. 2013) tested raw, thermized, and pasteurized milk for presence of *C. burnetti* genetic material and then tested potential cultures in mice via oral exposure. There were significantly more raw milk samples with the bacteria's genetic material, although some pasteurized milk still tested positive. However none of the mice in the study displayed any illness. The authors consider that pasteurization likely kills *C. burnetti* but may not completely remove its harmless genetic material.

Certain types of bacteria are able to form endospores, a dormant state where bacteria are resistant to extreme conditions such as heat. Endospore-forming bacteria include *Bacillus*, *Paenibacillus* (De Jonghe et al. 2010; Huck et al. 2007; Scheldeman et al. 2004), and *Clostridium botulinum* (Lindstrom et al. 2010). The bacteria genus *Bacillus* contains several pathogenic species. (De Jonghe et al. 2010) detected heat-resistant toxins from *B. amyloliquefaciens* and *B. subtilis* in raw milk, which can cause food poisoning. (Banyko and Vyletelova 2009) found similar concentrations of *B. cereus* and *B. licheniformis* in raw and pasteurized milk, and based on genetic fingerprinting determined that most contamination is occurring at points post-pasteurization for pasteurized milk. In (Huck et al. 2007), investigators isolated some of the same strains of *Bacillus* and *Paenibacillus* bacteria in both pasteurized and raw milk, suggesting that these bacteria are not killed during HTST pasteurization. Some *Paenibacillus* strains have even been isolated from UHT-pasteurized milk (Scheldeman et al. 2004).

There is a growing concern that milk, due to its wide distribution, storage in bulk tanks, rapid shelf life, and high consumption rates among humans, could be a prime target for bioterrorist attacks. (Newkirk et al. 2011) discusses this topic at length and mentions the potential for very potent pathogens such as *Clostridium botulinum* bacteria, which produce both endospores and deadly neurotoxins, to be used as a weapon. While these bacteria are not commonly found in milk, there are concerns they could be intentionally introduced as part of a bioterrorist plot. (Weingart et al. 2010) found that HTST pasteurization of raw milk removed 99.99% of isolated botulism neurotoxins and 99.5% of the neurotoxin complexes, the latter being the more dangerous form. (Perdue et al. 2003) grappled with the possibility of an anthrax attack on the milk production system. Anthrax is an infection spread by endospores from *Bacillis anthracis*. This study showed that anthrax spores are highly heat resistant. Two rounds of pasteurization could kill most spores, but up to 1% survived. These investigators determined that while pasteurization certainly seems to reduce the threat of an intentional outbreak, it would not prevent it. However these investigators note that failing to pasteurize bulk tank milk could significantly elevate the risk of an effective and potentially life-threatening bioterrorist attack.

An important problem in public health is the increasing prevalence of antibacterial resistance. Antibiotics are widely administered to dairy cows to prevent mastitis, which may result in bacteria developing drug resistance in our dairy products. Many of the antibiotics used in animals are the same ones used to treat infections in humans. Therefore, human diseases caused by these resistant bacteria could not be treated with conventional drugs. (Manie et al. 1999) characterized the prevalence of antibiotic resistant bacteria in pasteurized and raw milk samples in South Africa. When looking at total aerobic bacteria, a higher level of tetracycline resistance was seen in raw milk than in pasteurized milk. However, resistance to oxacillin, vancomycin, and methicillin were higher in pasteurized milk than in raw milk. The authors state that the bacteria detected in pasteurized milk may be due to post-pasteurization contamination. The mixed results from this study do not lead to a conclusion regarding the risks of raw versus pasteurized milk, but this study highlights important issues regarding antibiotic resistant bacteria. While another article claims the risk of antibiotic-resistant bacteria is currently not a concern for dairy products, the authors also argue that, if resistance began to occur on dairy farms, there would be a much greater concern for individuals consuming raw milk (Oliver and Murinda 2012).

Allergies, lactose intolerance, and milk consumption

In recent years there have been claims that drinking raw milk can attenuate the effects of lactose intolerance. However, studies have shown that pasteurization does not substantially change the lactose content in milk (Ijaz 2013; Lejeune and Rajala-Schultz 2009). Recently a group of researchers undertook a randomized control pilot study to observe the effects of raw milk on lactose intolerance and malabsoprtion (Mummah et al. 2014). The study compared 16 adults who each drank organic raw whole milk, organic pasteurized whole milk and plain soymilk over different intervals of time. Study participants were blinded to the milk they were drinking and the order of drinks was randomized for each participant. Individuals drinking raw milk unexpectedly showed higher lactose malabsoprtion (i.e. greater hydrogen excretion during a breath test) when compared to pasteurized milk. Furthermore, self-reported symptoms of lactose intolerance were not significantly different between raw milk and pasteurized milk. The authors concluded that raw milk does not reduce lactose intolerance, but recommended that additional studies with larger study groups should be conducted.

There have also been claims that raw milk consumption protects against the development of allergies. A meta-analysis of the literature on this topic supports these claims (Macdonald et al. 2011). The most interesting and compelling of these works was a case-control study on school-age children residing in rural areas of Germany, Austria, and Switzerland (Loss et al. 2011). Investigators used a questionnaire, took milk samples from a subset of participants' homes, and directly assessed the prevalence of asthma, atopy, and hay fever among the participants. Raw milk consumption had a substantial and statistically significant inverse association with all three allergic conditions when compared to pasteurized milk (usually UHT). From milk samples the researchers found that the inverse association with asthma was related to higher whey protein, lactalbumin, and lactoglobulin concentrations in raw milk. Total fat content and viable bacteria concentrations had no relationship to any of the allergenic conditions. While this study may suffer from selection bias, and does not measure life-long exposure to raw and pasteurized milk, its findings are significant and warrant further study. Future comparisons of allergic conditions comparing UHT milk with lower temperature pasteurized milk would also be informative.

Another article reviewed other studies investigating the relationship between unprocessed cow's milk and childhood allergies (von Mutius 2012). Two studies in different populations showed similar associations to (Loss et al. 2011). One report found higher immunoglobulin E (IgE) in cord blood from mothers who drank boiled milk during pregnancy as opposed to those who drank unboiled raw milk. This study also found higher toll-like receptor (TLR) expression in infants of mothers who drank unboiled milk. These findings support a more subdued autoimmunological response, which could explain the reduced allergic reactions observed in the children exposed to raw milk (von Mutius 2012). (Baars 2013) & (Perkin 2007) describe small epidemiological studies that have found similar trends. While the findings from these epidemiological studies are compelling, their results have been heterogeneous, with varying associations of raw milk and allergic symptoms (e.g. asthma, atopy, allergenic rhinitis, etc.). The reasons for this heterogeneity are still unclear.

These epidemiological findings have spurred experimental studies that further investigate how milk composition affects immunological responses. Heat treatment of milk can simultaneously denature some protein structures and aggregate or create others (Baars 2013). One recent study examined caseins and whey proteins from cow's milk given to mice (Shandilya et al. 2013). Mice were injected with raw, pasteurized, or sterilized (heated to 120 °C for 20 minutes) milk. Mice exposed to pasteurized milk had more IgE and IgG in the serum, while those exposed to raw or sterilized milk did not. The authors believed these observations were related to changes in the structure of caseins and whey proteins. These findings may be related to milk content associations with allergies found in (Loss et al. 2011) and (von Mutius 2012).

This biological pathway, however, is not consistently observed. In a recent study, mice were fed water, raw milk, UHT milk, or gamma-sterilized milk, which kills viable bacteria but will not alter protein content (Hodgkinson et al. 2014). Mice fed raw milk had a relatively higher IgE response as well as higher mast cell and interleukin-10 concentrations than mice fed pasteurized milk. Most importantly, mice fed raw milk had the most severe allergen response of all experimental groups. These mice however were exposed for only a short period of time, and the high interleukin-10 concentrations observed may indicate that allergic regulation occurs after long-term exposure to raw milk. Interestingly, this study also showed that mice fed raw milk had more active immune responses than those fed gamma-sterilized milk, implying that viable bacteria, and not proteins, are the more important components of raw milk. The importance of microbial diversity in milk has also been hypothesized elsewhere (Baars 2013). Other research has focused on the role of fatty acids, and that homogenization or dairy-farming factors independent of pasteurization may have a significant influence on allergic responses (Baars 2013; Perkin 2007). More research is needed to better understand the relationship between raw milk and allergies.

It is important to note that the epidemiological studies in this section were almost always limited to rural populations. Since individuals living on farms are the most frequent consumers of raw milk, it is not certain whether these findings can be extrapolated to children who live in more urban settings. Children living in rural areas are usually directly or indirectly exposed to farm animals, which may be associated with lower prevalence of allergies (Loss et al. 2011). Urban residents who have little or no contact with farm animals may have a qualitatively different immunological response to raw milk consumption. To our knowledge, such a population has yet to be evaluated to address this research question.

Furthermore, every article we reviewed that evaluated the relationship of raw milk to allergies or lactose intolerance cautioned against consuming raw milk. The authors of each of these studies recognize that the potential exposure of pathogenic microbes in raw milk may be far more harmful than any possible benefits raw milk may provide. Some of the authors state that this line of research will be most helpful by identifying the components of raw milk that are beneficial to reducing allergies. These authors believe this information can be used to determine a way to process milk that maintains these components while still removing hazardous pathogens.

Non-microbial hazards in milk and other public health risks

Only a few articles focused on non-infectious or allergy-related public health risks. One study looked at concentrations of estrogenic hormones in milk. Estrogen is naturally secreted in lactating cows. One study found that concentrations of estrogen in raw and pasteurized milk were related to cow pregnancy status, with cows in their third trimester secreting the most estrogen (Malekinejad et al. 2006). Estrogen concentrations were also associated with the fat content of the milk, with whole milk containing more estrogen than skim milk. Raw milk did have significantly higher concentrations of estrogen than pasteurized milk, but only in autumn samples, which may imply a seasonal effect in hormone secretion. Another article considered antibiotics in milk (Oliver and Murinda 2012). Antibiotics are usually given to cows to prevent mastitis. The article states that higher residues of antibiotics are found in raw milk, and that pasteurization will reduce concentrations. A smaller, recent study of antibiotic residues in animal products found very low levels of tetracycline antibiotics in two of three analyzed pasteurized milk samples (Baron et al. 2014); the same study noted low-level residues of acetaminophen in all pasteurized milk samples tested. Another study performed a meta-analysis on the association of raw milk consumption and the risk of cancer, however no association was found (McDonald et al. 2005). Evidence of raw milk having protective effects on diabetes, osteoporosis, and arthritis incidence is also lacking (Ijaz 2013).

Milk nutrition

As stated above, articles devoted solely to comparing the nutritional content of raw versus pasteurized milk were not considered. Some articles, however, did mention nutrition along with public health risks and are summarized here. One review article provided a summary of previous nutrition literature (Lejeune and Rajala-Schultz 2009). Lactoferrin and lysoszymes, milk proteins that can prevent bacterial proliferation, do not significantly differ between raw or pasteurized milk, and only slight differences are found when milk is HTST or UHT pasteurized. Bovine immunoglobulins as well as oligosaccharides and bacteriocins, all of which can prevent bacterial infections, were not different between pasteurized and raw milk samples. However, lactoperoxidase, a bacteriostatic enzyme, was reduced by 30% when pasteurized, and concentrations decreased after higher-temperature pasteurization.

Both the review above and a meta-analysis study compared the vitamin concentrations in raw versus pasteurized milk (Lejeune and Rajala-Schultz 2009; Macdonald et al. 2011). Vitamins D, E and K do not appear to decrease substantially after pasteurization of milk. Vitamin A, of which milk is an important source, actually increased in concentrations after pasteurization. Vitamin B12 and E were found to significantly decrease after pasteurization, however milk is not considered an important source of either of these vitamins. Vitamin B2, also known as riboflavin, did have lower concentrations in pasteurized milk when compared to raw milk and this difference was statistically significant. While milk is a popular source of riboflavin and its loss in pasteurized milk is substantial, there are many other common foods that could supplement any potential vitamin deficiency in consumers of pasteurized milk.

Articles submitted by proponents

Proponents of the recent bill sent us a number of articles for consideration. Some of these have been included in the results above. Please see **Appendix D** for a complete listing of the articles we received as well as reasons we included or excluded these articles from our review. Many articles did not fit our pre-specified scope for our literature review, or did not compare raw and pasteurized milk. We also excluded information that came from non-peer-reviewed secondary sources, such as media outlets.

We would like to note that the research on the microbiome and its effects on human health is in its infancy and that there is no direct evidence to suggest that microbial exposures have a net benefit to the human health. While we agree there should be scientific investigations into the effects of milk on the human microbiome, we do not believe claims regarding the microbiome are currently scientifically relevant to raw milk (Ijaz 2013; von Mutius 2012).

Discussion

There are inherent risks in consuming both raw and pasteurized milk; pasteurization is not a sterilization technique and post-pasteurization contamination can occur (Lejeune and Rajala-Schultz 2009). The articles we reviewed, however, clearly suggest that the risk of microbial hazards in raw milk is substantially higher than in pasteurized milk. Further, raw milk is more likely to contain pathogens that are harmful to susceptible populations such as young children, the elderly, and individuals with chronic illnesses. Some of the articles we reviewed seem to imply that infection rates between raw and pasteurized milk are similar or are lower for raw milk. Such an interpretation however does not take into account the substantial differences in consumption frequency. Current estimates are that raw milk is consumed by no more than 3.5% of the U.S. population (Committee on Infectious Diseases and Committee on Nutrition of the American Academy of Pediatrics 2014; David 2012). If this proportion were to increase, then the number of infectious outbreaks caused by consuming raw milk would also rise. These infection rates would likely be greater than current rates for pasteurized milk.

Our results show that heat-treatment of milk creates no noticeable difference in lactose intolerance. Drinking raw milk early in life or during pregnancy, however, does seem to be associated with lower prevalence of allergies. The biological mechanism for this proposed relationship is still unclear, and may be due to whey proteins, bovine immunoglobulins, or microorganisms in raw milk (Hodgkinson et al. 2014; Melnik et al. 2014; von Mutius 2012). Each of the articles we reviewed from our database search that focused on this topic explicitly stated such results do not support drinking raw milk. Most of these articles also stated they do not recommend drinking raw milk, as the risk of microbial contamination is too serious.

A few articles reviewed the risks of other contaminants or changes in the nutritional value of milk. These findings were overall mixed and none demonstrated that raw milk had clear public health benefits compared to pasteurized milk.

Formally evaluating whether the public health benefits of raw milk "outweigh" any health risks would require a comprehensive risk assessment that included all potential hazards (i.e. every pathogenic microbe) as well as all potential health benefits. Ideally, this risk assessment would simultaneously compare the risks and benefits of pasteurized milk. No such analysis has been performed. To our knowledge, only one risk assessment of *Listeria monocytogenes* has formally compared raw and pasteurized milk, and this assessment admittedly had a high uncertainty (Whiting et al. 2003). Reviewing meta-analyses, such as the one performed by (Macdonald et al. 2011), are useful, but to our knowledge no meta-analysis has considered all health risks and benefits simultaneously.

Based on our review of the scientific literature, we believe that there is no scientific evidence supporting the claim that the benefits of raw milk outweigh any health risks. The risk of microbial contamination in food products is measurable, and has been a concern throughout recent times (Scallan et al. 2011). The sources of microbial contaminants have not diminished in the last century and the opportunity for new microbial contaminants resistant to antibiotics is real (Mendelson 2011; Oliver and Murinda 2012). Pasteurization has been shown to reduce the risk of almost all microbial and other contamination in milk products.

While a few studies have shown an interesting association between raw milk and reduced allergies, this has not been proven to be a causal relationship, nor has a biological pathway been confirmed (van Neerven et al. 2012). Further, the evidence implies that this association may only be observed if milk is consumed by pregnant mothers or young children, populations that are also very susceptible to infectious organisms sometimes present in milk. Changes in nutritional value due to pasteurization appear to be marginal and would only become a health concern if an individual were not consuming a well-balanced diet (Macdonald et al. 2011). From a health and safety perspective, it seems more appropriate to defer to pasteurizing milk rather than assume that the risk of microbial contamination is negligible.

Further scientific investigation of raw milk is warranted, ideally to identify the beneficial components of raw milk and how to preserve these during processing. Many of the articles that focused on public health benefits of raw milk such as (Loss et al. 2011) restricted their comparisons to HTST and UHT pasteurized milk. These intensive heat treatments can denature proteins in milk such as caseins and beta-lactoglobulin (Walstra et al. 2006), which have been identified as potential sources of reduced allergic reactions from drinking raw milk (Baars 2013). These modern types of pasteurization may also lead to the "cooked" flavor in milk that some find unpleasant (Walstra et al. 2006). Classic pasteurization (i.e. 63°C for 30 minutes), which is now uncommon in industrialized milk production, does not create such irreversible changes and so may still be able to maintain the healthy components of raw milk while removing harmful pathogens (Lejeune and Rajala-Schultz 2009; Walstra et al. 2006). We believe future studies should compare health benefits of raw milk with milk that is mildly pasteurized. Homogenization is also not required for pasteurization and forgoing it could also help retain beneficial components of milk, such as caseins and whey proteins (Ijaz 2013; Perkin 2007; von Mutius 2012). There are also other forms of milk processing, such as food irradiation, high pressure, carbon dioxide, and filtration, which can be as effective as pasteurization at removing pathogens but do not require heat treatment (Elwell and Barbano 2006; Loaharanu 1996; Ruiz-Espinosa et al. 2013). Whether these varying food safety techniques also alter the claimed health benefits of raw milk should be further investigated.

It is important to reiterate the systematic differences between most raw and pasteurized milk production in the U.S. and how they complicate the public health argument for one or the other (Mendelson 2011). Today most pasteurized milk is produced at an industrial scale, with farms containing thousands of cows fed corn and soy predicts, and milk sent to dairy processing plants in bulk tanks. Dairy farmers at these industrial farms have the opportunity to be more lax about hygienic practices. Further, the potential for cross-contamination of milk before or after pasteurization is substantial due to these potential factors: a large number of workers, biofilms in distribution pipes, and unsterilized equipment (Mendelson 2011; Oliver et al. 2005).

On the other hand, milk that is intentionally sold unpasteurized is often produced on small farms with grass-fed cows and sold to local consumers (Baars 2013). While hygienic practices are not ensured in this setting, these farmers may be more concerned for each individual animal's health and the health of their customers. They thus may strive to prevent microbial or other contamination. We believe in the benefit of consuming milk and other food products on a local scale, as it is both environmentally sustainable and can support the local economy. We also recognize this can be difficult to achieve given the stringent FDA standards of milk production and processing. We are convinced, however, that there are opportunities for small-scale farmers to feasibly provide milk that is free of microbial contaminants. Such options could include: purchasing and maintaining co-operative pasteurization equipment, implementing other food safety processing techniques mentioned above, maintaining strict hygienic standards for cows and workers, and performing microbial tests on milk intended for consumption (Baars 2013).

We believe that our report provides an unbiased comparison of the public health literature on raw and pasteurized milk. While we understand the position of raw milk advocates about the low number of reported foodborne illnesses caused by raw milk, we believe they take an important misstep by failing to account for the low prevalence of raw milk consumption in the United States. If consumption of raw milk increased, then the number of illnesses would quickly outpace those attributed to pasteurized milk. Even more illnesses would occur if raw milk was sold using the aforementioned industrialized production system, as has been seen in California (Garber 2008). Advocates also claim that raw milk may actually be safer than other non-dairy food products, as fewer illnesses are reported or estimated (Ijaz 2013). While there may be some validity in this statement, one must take into account the severe underreporting of all foodborne illnesses including those from pasteurized and raw milk, as well as the high frequency of milk consumption. It is believed that the number of individuals actually succumbing to foodborne illness from consuming raw milk is likely far higher than the numbers reported in outbreaks (Scallan et al. 2011).

We would be remiss to ignore in this review the continuing disagreements of raw milk proponents and federal regulatory agencies (Mendelson 2011). While we understand the positions of both groups, we strongly believe that both parties would gain much by being willing to discuss and compromise on their positions.

In conclusion, given the scientific evidence, we do not recommend the consumption of raw milk. If raw milk sales became legal in Maryland, we would strongly recommend that a labeling system be implemented and that farm safety and hygienic practices be required. We would also recommend restricting pregnant women and children from drinking raw milk due to their increased susceptibility to microbial hazards.

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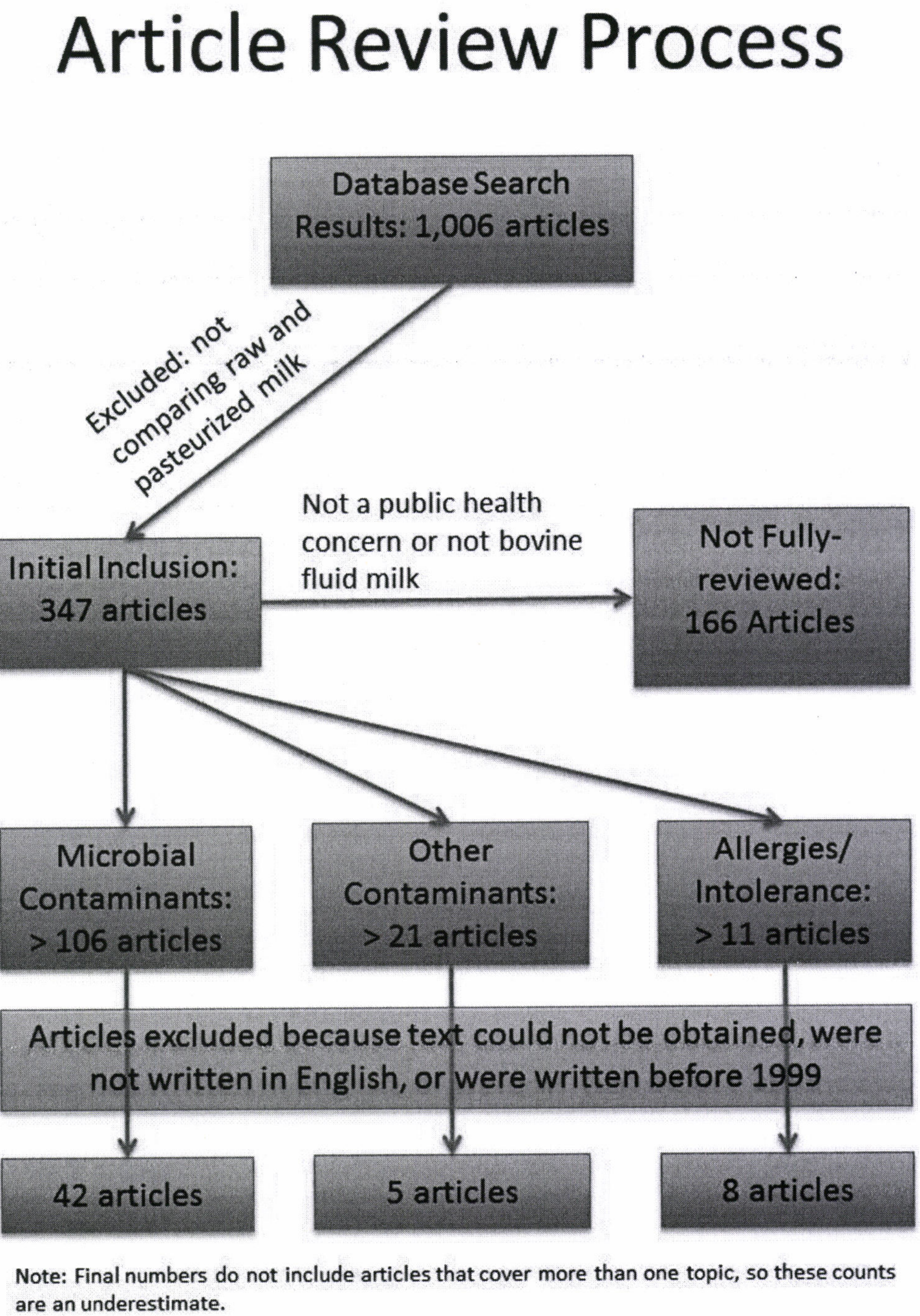
Temperature	Time (s)
63°C (145°F)	1800
72°C (161°F)	15.0
89°C (191°F)	1.0
90°C (194°F)	0.5
94°C (201°F)	0.1
96°C (204°F)	0.05
100°C (212°F)	0.01

Table 1. Temperature and time combinations for fluid milk pasteurization approved by the U.S. Food and Drug Administration. Adapted from (Lejeune and Rajala-Schultz 2009).



<u>Figure 1</u>. Database search review process

Appendices

Appendix A: Search terms for the PubMed database

("Pasteurization"[Mesh] OR Pasteuriz*[tw] OR Pasteuris*[tw] OR boiled[tw] OR boiling[tw] OR "Sterilization"[Mesh] OR sterilize*[tw] OR sterilis*[tw] OR UHT[tw] OR Ultra-high-temperature[tw] OR processed*[tw] OR microwaved*[tw])

AND

(raw[tw] OR unpasteuriz*[tw] OR unpasteuris*[tw] OR unsteriliz*[tw] OR unsterilis*[tw])

AND

("Milk"[Mesh] OR milk[tw] OR "Dairy Products"[Mesh] OR Dairy[tw])

***Appendix B**: List of categories created for articles "initially included"*

Categories in which articles were fully reviewed (if text was available)

- Review articles (n=43): articles covered a broad range of topics comparing unpasteurized and pasteurized milk and dairy products.
- Microbial Contamination (n=106): Articles primarily focused on potential pathogenic bacteria presence and persistence in fluid bovine milk.
- Other Contaminants (n=21): Articles focused primarily on chemical and fungal contaminants in milk, such as antibiotics, metals, and aflatoxin.
- Allergies/Intolerance: Articles focused on the effects of milk (unpasteurized and pasteurized), usually atopic allergic reactions or lactose intolerance.

Categories in which articles were not considered for full review

- Developing Country Articles (n=35): Articles that focused, primarily on the adverse health effects of consuming raw milk in rural impoverished areas, most commonly in African and South/Central American countries. These articles were not considered due to the likely confounding of unhygienic practices in milking, distribution and storage when comparing raw and pasteurized milk.
- Outbreaks & Case-studies (n=26): Articles that focus on microbial outbreaks with dairy products being the vehicle of transmission. These articles did not directly compare raw and pasteurized milk.
- Microbiome (n=5): Articles that considered the potential benefits on intestinal microflora by consuming raw or pasteurized milk.
- Nutrition and Flavor (n=43): Articles that compared nutritional content and flavor structure of both raw and pasteurized milk.
- Shelf-life & Spoilage (n=8): Articles that compared how long unpasteurized and pasteurized milk could be stored.
- Cheese Health Risks (n=30): Articles that focused solely on the health risks (e.g. pathogenic microbial contamination) of consuming raw versus pasteurized cheese products.
- Cheese Health Benefits (n=10): Articles that focused solely on the health benefits (e.g. nutrition and flavor) of consuming raw versus pasteurized cheese products.
- Goat Milk (n=7): Articles that were restricted only to comparisons of raw versus pasteurized goat milk.
- Other Dairy products (n=2): Articles that focused solely on dairy products that were not fluid milk or cheese (e.g. buttermilk).

Appendix C: List of articles fully reviewed from PubMed Database Search

1. Child Health Alert. 2009. Unpasteurized milk--still a health threat. Child health alert 27:5.
2. U.S. Centers for Disease Control and Prevention.. 2013. Vital signs: Listeria illnesses, deaths, and outbreaks--united states, 2009-2011. MMWR Morbidity and mortality weekly report 62:448-452.
3. Committee on Infectious Diseases and Committee on Nutrition of the American Academy of Pediatrics.. 2014. Consumption of raw or unpasteurized milk and milk products by pregnant women and children. Pediatrics 133:175-179.
4. Alhelfi NA, Lahmer RA, Jones DL, Williams AP. 2012. Survival and metabolic activity of lux-marked escherichia coli o157:H7 in different types of milk. The Journal of dairy research 79:257-261.
5. Alisky J. 2009. Bovine and human-derived passive immunization could help slow a future avian influenza pandemic. Medical hypotheses 72:74-75.
6. Ayele WY, Svastova P, Roubal P, Bartos M, Pavlik I. 2005. Mycobacterium avium subspecies paratuberculosis cultured from locally and commercially pasteurized cow's milk in the czech republic. Applied and environmental microbiology 71:1210-1214.
7. Baek SY, Lim SY, Lee DH, Min KH, Kim CM. 2000. Incidence and characterization of listeria monocytogenes from domestic and imported foods in korea. Journal of food protection 63:186-189.
8. Banyko J, Vyletelova M. 2009. Determining the source of bacillus cereus and bacillus licheniformis isolated from raw milk, pasteurized milk and yoghurt. Letters in applied microbiology 48:318-323.
9. Bhatti M, Veeramachaneni A, Shelef LA. 2004. Factors affecting the antilisterial effects of nisin in milk. International journal of food microbiology 97:215-219.
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11. Cerva C, Bremm C, Reis EM, Bezerra AV, Loiko MR, Cruz CE, et al. 2014. Food safety in raw milk production: Risk factors associated to bacterial DNA contamination. Tropical animal health and production 46:877-882.
12. David SD. 2012. Raw milk in court: Implications for public health policy and practice. Public health reports (Washington, DC : 1974) 127:598-601.
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16. de la Rua-Domenech R. 2006. Human mycobacterium bovis infection in the united kingdom: Incidence, risks, control measures and review of the zoonotic aspects of bovine tuberculosis. Tuberculosis (Edinburgh, Scotland) 86:77-109.
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18. Eltholth MM, Marsh VR, Van Winden S, Guitian FJ. 2009. Contamination of food products with mycobacterium avium paratuberculosis: A systematic review. Journal of applied microbiology 107:1061-1071.
19. Freitas R, Nero LA, Carvalho AF. 2009. Technical note: Enumeration of mesophilic aerobes in milk: Evaluation of standard official protocols and petrifilm aerobic count plates. Journal of dairy science 92:3069-3073.
20. Fujimura S, Kawamura T, Kato S, Tateno H, Watanabe A. 2002. Detection of helicobacter pylori in cow's milk. Letters in applied microbiology 35:504-507.
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22. Garber K. 2008. Drinking it raw-or not. Health officials face off with farmers over unpasteurized milk. US news & world report 144:25.
23. Giacometti F, Serraino A, Bonilauri P, Ostanello F, Daminelli P, Finazzi G, et al. 2012. Quantitative risk assessment of verocytotoxin-producing escherichia coli o157 and campylobacter jejuni related to consumption of raw milk in a province in northern italy. Journal of food protection 75:2031-2038.
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27. Grant IR, Ball HJ, Rowe MT. 2002. Incidence of mycobacterium paratuberculosis in bulk raw and commercially pasteurized cows' milk from approved dairy processing establishments in the united kingdom. Applied and environmental microbiology 68:2428-2435.
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30. Hodgkinson AJ, McDonald NA, Hine B. 2014. Effect of raw milk on allergic responses in a murine model of gastrointestinal allergy. The British journal of nutrition 112:390-397.
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46. Massa S, Goffredo E, Altieri C, Natola K. 1999. Fate of escherichia coli o157:H7 in unpasteurized milk stored at 8 degrees c. Letters in applied microbiology 28:89-92.
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81. Weingart OG, Schreiber T, Mascher C, Pauly D, Dorner MB, Berger TF, et al. 2010. The case of botulinum toxin in milk: Experimental data. Applied and environmental microbiology 76:3293-3300.

***Appendix D**: Articles Submitted by Bill Proponents*

Status	**Citations**
Included	
Found through original PubMed database search	(Doyle and Roman 1982; Loss et al. 2011; van Neerven et al. 2012)
Relevant to our literature review scope	(Baars 2013; Brown et al. 2012; Ijaz 2013; Perkin 2007; Walstra et al. 2006; Whiting et al. 2003)
Excluded	
Not related to milk	(Borody et al. 2014; Desch and Motto 2007; Ganguli and Walker 2011; 2012)
Limited to non-fluid dairy products	(Sanaa et al. 2004)
Limited to milk nutrition	(Haug et al. 2007; Oberleas and Prasad 1969; Patton 1999; Ward and German 2004; Zurera-Cosano et al. 1994)
Limited to cow treatment, not pasteurization	(Dhiman et al. 1999; Said et al. 1989).
Did not distinguish between raw and pasteurized milk	(Baker et al. 2007; Kothary and Babu 2001; Waser et al. 2007)
Not peer-reviewed literature	(Green 2014; Gumpert 2013, 2014; Hartke 2012; Michigan Fresh Unprocessed Whole Milk Workgroup 2012)